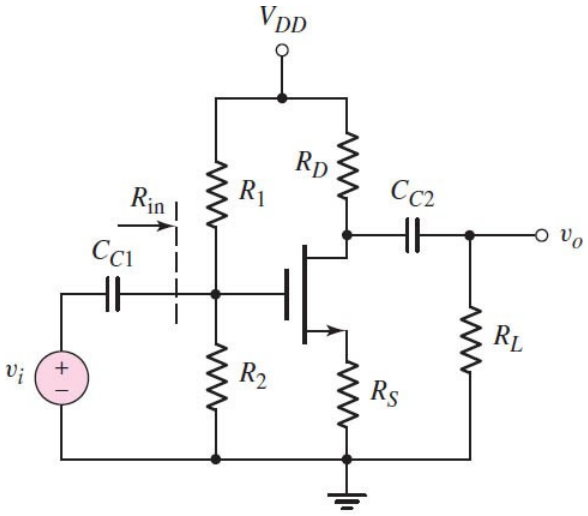
ECE322L –Homework 2 (100 points)
Assigned on Thursday, 02/06/2020-11 am
Due on Thursday, 02/13/2020-11 am

SOLUTION

For the NMOS common-source amplifier in Figure P4.15, the transistor parameters are: $V_{TN} = 0.8$ V, $K_n = 1$ mA/V^2, and $\lambda = 0$. The circuit parameters are $V_{DD} = 5$ V, $R_S = 1\ \text{k}\Omega$, $R_D = 4\ \text{k}\Omega$, $R_1 = 225\ \text{k}\Omega$, and $R_2 = 175\ \text{k}\Omega$. (a) Calculate the quiescent values I_{DQ} and V_{DSQ}. (b) Determine the small-signal voltage gain for $R_L = \infty$. (c) Determine the value of R_L that will reduce the small-signal voltage gain to 75 percent of the value found in part (b).



(a) $$V_G = \left(\frac{R_2}{R_1 + R_2}\right) \cdot V_{DD} = \left(\frac{175}{175 + 225}\right)(5) = 2.1875 \text{ V}$$

$$2.1875 = V_{GS} + I_D R_S = V_{GS} + K_n R_S (V_{GS} - V_{TN})^2$$

$$2.1875 = V_{GS} + (1)(1)(V_{GS}^2 - 1.6V_{GS} + 0.64)$$

or $$V_{GS}^2 - 0.6V_{GS} - 1.5475 = 0 \Rightarrow V_{GS} = 1.58 \text{ V}$$

$$I_{DQ} = K_n (V_{GS} - V_{TN})^2 = (1)(1.58 - 0.8)^2 = 0.608 \text{ mA}$$

$$V_{DSQ} = V_{DD} - I_{DQ}(R_S + R_D) = 5 - (0.608)(1 + 4) = 1.96 \text{ V}$$

(b) $$A_v = \frac{-g_m R_D}{1 + g_m R_S}$$

$$g_m = 2\sqrt{(1)(0.608)} = 1.56 \text{ mA/V}$$

$$A_v = \frac{-(1.56)(4)}{1 + (1.56)(1)} = -2.44$$

(c) $$A_v = \frac{-g_m (R_D \| R_L)}{1 + g_m R_S} = \frac{-(1.56)(R_D \| R_L)}{1 + (1.56)(1)} = -0.6094(R_D \| R_L)$$

$$-(0.75)(2.44) = -(0.6094)(R_D \| R_L) \Rightarrow R_D \| R_L = 3.0\ \text{k}\Omega$$

$$4 \| R_L = 3 \Rightarrow R_L = 12\ \text{k}\Omega$$

Please, see lecture 6, slides 18-20 for the small-signal analysis